THE SOMATIC CHROMOSOMES OF *NICANDRA*

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Nicandra is a monotypic genus of the *Solanaceæ*, the solitary species being *Nicandra physaloides* represented by several varieties. In Index Kewensis, *Nicandra violacea* is mentioned as a separate species, but it has been described as a variety of *N. physaloides* by Darlington and Janaki-Ammal (1945). The material described in the present paper consisted of two forms, one being *N. physaloides* var. *arbiflora* from the Royal Botanic Gardens, Edinburgh, and the other supplied as *N. violacea* from the Royal Botanic Gardens, Kew.

The first chromosome counts in *N. physaloides* were made by Vilmorin and Simonet (1927) who reported $2n = 20$. This was later confirmed by Janaki-Ammal (1932), who studied the cytology of two varieties, namely, 'immaculata' and 'typica', but did not find any difference between the two. She has divided the somatic chromosomes into five classes according to size and has observed the homologous chromosomes to be associated in pairs in the resting nuclei of the somatic cells. In view of the chromosome morphology she has suggested a close phylogenetic relationship between *Nicandra* and *Datura*. Darlington and Janaki-Ammal (1945), however, have found $n = 9$, 10 and $2n = 19$, 20 and have also counted 40 somatic chromosomes in the artificial autotetraploid plants. According to them, there are present in the somatic set nine pairs of autosomes and one pair of isochromosomes. During meiosis, the isochromosomes pair either inside to form univalents or outside to form bivalents or both. When univalents are lost, pollen and eggs are formed lacking one isochromosome altogether. After fusion of such a gamete with a normal one, plants are produced with $2n = 19$.

The present counts differ from the above in that the somatic number was found to be $2n = 21$ both in *N. physaloides* var. *arbiflora* and *N. violacea*. All the somatic metaphase plates examined showed a twenty-first element in the form of a fragment (Figs. 1, 2 and 3).

In the somatic plates, the fragment is seen situated close to a particular chromosome which is apparently different from the rest and is probably the third smallest in size. The other chromosomes, in both, range in size from large to medium except for two chromosomes in each which are the smallest. In morphology, the chromosomes of the two forms are very similar (Figs. 1 and 2) which shows that *N. violacea* does not deserve the rank of a separate species. Nearly half

1 2 3

FIGS. 1, 2 & 3. For explanation see text.

the number of chromosomes in *N. physaloides* var. *arbiflora* and four in *N. violacea* have two constrictions and the remaining chromosomes have either a median, sub-median or sub-terminal spindle-attachment. Of the chromosomes with two constrictions, there are two in each which have both the ends in the form of a knob. In the representative somatic plate of three varieties (excepting *violacea*) presented by Darlington and Janaki-Ammal, only one pair of such chromosomes can be distinguished which they have described as isochromosomes; the rest of the chromosomes apparently have either a median, sub-median or sub-terminal constriction. In two of these varieties Janaki-Ammal reports all the chromosomes to have a median constriction. The region of primary constriction is very slender and some of the chromosomes are pointed at one end. No satellites were observed in either *N. physaloides* var. *arbiflora* or *N. violacea* as also reported by the previous workers.

While there is similarity between the chromosomes of the two forms, sometimes striking variation is to be noticed between different somatic plates of *N. violacea* as regards the size and shape of the chromosomes. This can be seen from Figs. 1 and 3, in one of which the chromosomes are seen as they have been described whereas in the other (Fig. 3) they appear to be very condensed with a corresponding increase in thickness. The smaller arm in some of the chromosomes is seen like a very small knob and the region of constriction appears to be more slender and stretched.

In *Nicandra* we come across two different pictures. On the one hand, species formation appears to be at a standstill since *N. physaloides* is the only species and its few varieties or types are very similar cytologically. On the other hand, the somatic chromosomes are like those of the highly evolved genus *Solanum* (Sinha, 1950). This might mean that the chromosomes are of recent origin and the numbers $2n = 20$ or $2n = 21$ have been derived by the loss of certain chromosomes from an allied genus with $2n = 24$. Although from the present studies its nearest relative cannot be suggested with cetainty, *Nicandra* appears to be more allied to *Solanum* than to *Datura* (1932).

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STUDIES IN CÆSALPINIACEÆ

II. Development of the Endosperm and Embryo in *Cassia occidentalis* L.

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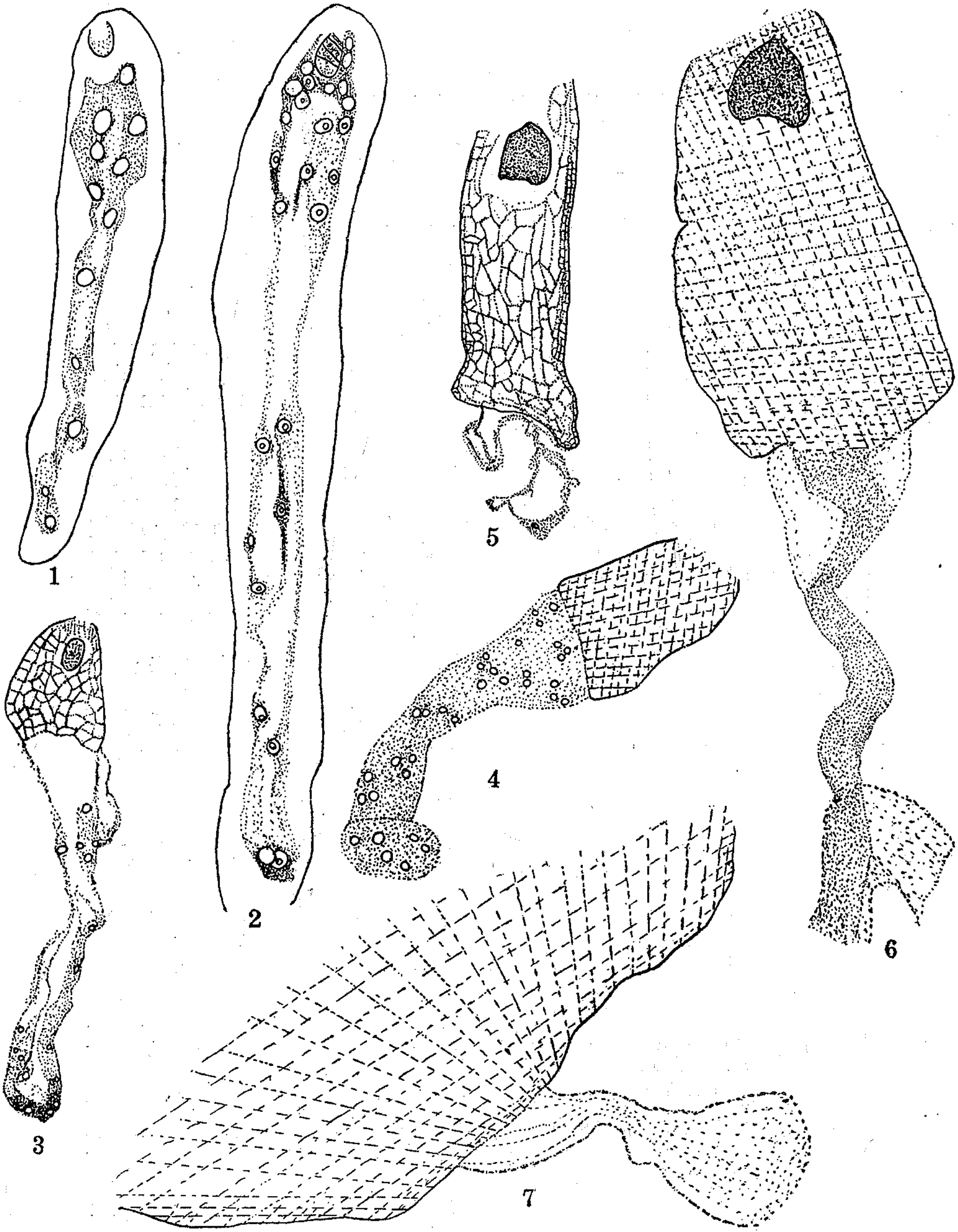
In a previous paper (Pantulu, 1945), the development of the embryo-sac in several species of the genus *Cassia* Linn. was described. The present paper deals with the development of endosperm and embryo in *Cassia occidentalis* L. The earliest work dealing with embryogeny of Cæsalpiniaceæ is that of Guignard (1881), who described some stages in the development of the embryo in *Cercis siliquastrum* and *Cæsalpinia mimosoides*. In the former, he observed an oblong proembryonic mass, which later on broadens at each end to form the embryo and suspensor, while in *Cæsalipinia mimosoides* he noted that the embryo becomes distinct rather early as a region of more actively dividing cells. Anantaswamy Rau (1950) has recently published a note on endosperm development in *Cassia tora* Linn.

The material was collected from plants growing wild at Guntur between 12–0 Noon and 2–0 p.m. and fixed in formalin acetic alcohol. After embedding in paraffin, sections were cut 10–14 μ thick and stained with Safranin and Brilliant Green and Safranin and Crystal Violet combinations.

Development of the Endosperm

After fertilisation the oospore rests for sometime, but the primary endosperm nucleus formed by triple fusion, which lies near the oospore, starts dividing immediately. By the time the osspore begins to divide, usually 16 endosperm nuclei are already formed. Some of these migrate towards the antipodal end and there comes about a nearly equal distribution of nuclei at the periphery of the embryo-sac (Fig. 1). Soon, however, the number of nuclei at the micropylar end increases (Fig. 2) and gradually there is also an increase in the number of nuclei and amount of cytoplasm at the chalazal end. Thus there develop micropylar and chalazal accumulations of endosperm.

The wall formation in the endosperm starts from the micropylar end and then spreads gradually towards the chalazal (Fig. 3). At the chalazal end, however, the endosperm remains free nuclear even after it has become cellular in the rest of the embryo-sac. This is very characteristic and in the later stages the chalazal part of the endosprm appears as a tubular haustorial structure at the end of the cellular part as noted by Rau (1950) in *Cassia tora* (Figs. 4–7). There is only one difference. According to Rau, one of the endosperm nuclei in the chalazal region is more prominent than the rest. In the present material



FIGS. 1–7. *Cassia occidentalis*.—Various stages in the development of endosperm. Figs. 1–3 and 5 are from longitudinal sections, while Figs. 4, 6 and 7 have been drawn from entire endosperms dissected out from growing seeds. Fig. 7 shows only the chalazal part of the endosperm at an advanced stage of development. Figs. 1–2, ×350; the rest, ×100.

no such single prominent nucleus was observed, but generally all the nuclei in the chalazal part are more prominent than nuclei in the rest of the endosperm. I have observed similar endosperm also in *Cassia auriculata* and *C. glauca.* It appears to be characteristic of the genus.

Another notable feature about the endosperm is that a thin layer of it persists around the embryo even in the mature seed. The seed is thus really endospermic. This feature deserves mention because the seeds of the Leguminosæ are usually described as non-endospermic.

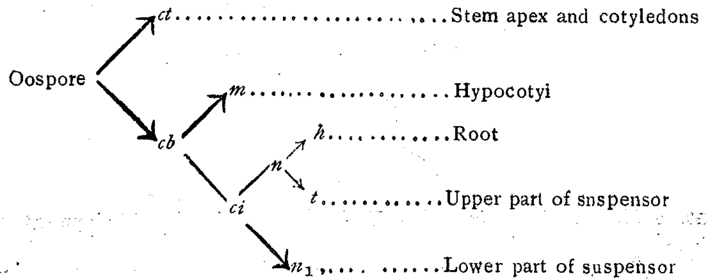
EMBRYO

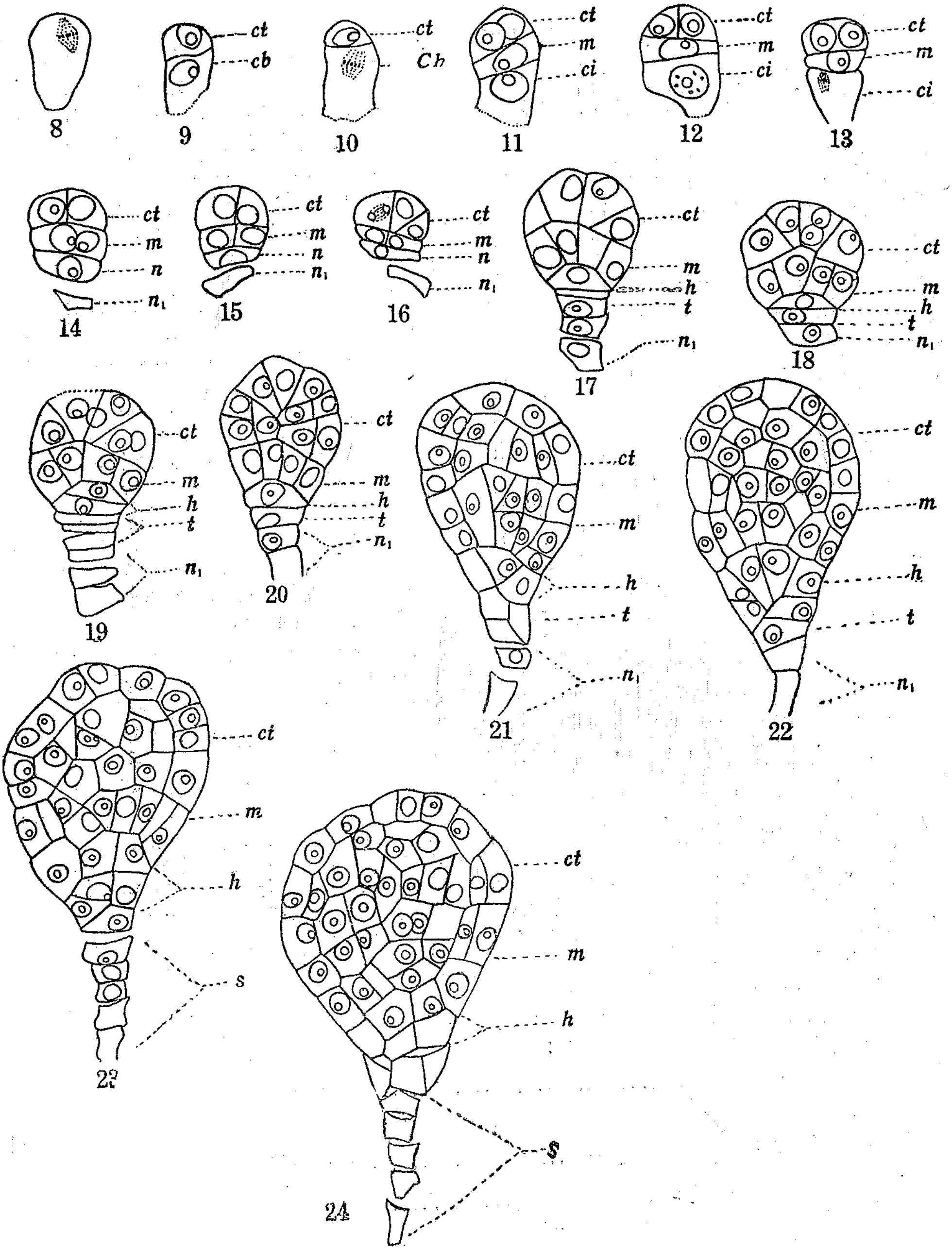
The first division of the oospore is transverse (Figs. 8 and 9). Out of the two daughter cells thus formed, the basal cell (the cell towards the micropyle) divides again transversely to give rise to a proembryo of three cells (Figs. 10 and 11). For the convenience of description these cells of the 3-celled proembryo may be designated as follows: the cell near the micropyle *ci*; the middle cell *m*; and the terminal cell *ct*. The further differentiation of these three cells is as follows:

The terminal cell of the 3-celled proembryo is the first to divide. It divides by a longitudinal wall to give rise to two juxtaposed cells (Figs. 11 and 13). This is followed by the transverse division of the cell *ci*, to give rise to two superposed cells *n* and n_1 (Figs. 13 and 14). Next division occurs in the middle cell of the three-celled proembryo, and the wall formed after the division is a longitudinal one (Figs. 14 and 15). The derivatives of the terminal cell and the middle cell undergo one more division to give rise to two tiers of four cells each (Figs. 16 and 17). Periclinal divisions now take place in the derivatives of the terminal cell. Thus the dermatogen is differentiated in this region (Figs. 19 and 20). This is soon followed by periclinal divisions and the differentiation of the dermatogen in the tier next to the apical one derived originally from the cell *m*.

The cell *n* divides transversely to give rise to two superposed cells *h* and *t*. The cell *h* functions as the hypophysis. It first divides transversely (Fig. 19) and ultimately gives rise to the entire root including the root-tip and root-cap (Figs. 23 and 24). The cell *t* undergoes one division and contributes along with the derivatives of the cell n_1 towards the formation of the suspensor, which ultimately becomes a filamentous structure several cells long.

The origin of the various parts of the embryo from the cells of the proembryo is as follows:





FIGS. 8–24. *Cassia occidentalis.*—Various stages in the development of the embryo. *ct.*, terminal cell; *m.*, middle cell; *ci.*, basal cell of the 3-celled proembryo; *n.*, upper daughter cell formed by the division of *ci.*; *n* , lower daughter cell; *h.*, the cell derived from the cell *n* by transverse division. ×1,130.

The embryo development in *Cassia occidentalis,* as derivatives of both the terminal cell and the basal cell of the 2-celled proembryo contribute to the formation of the embryo proper, follows the *Asterad* type of Johansen (1945). In this respect, it differs from embryo development observed in Papilionaceæ and Mimosaceæ. In several Papilonaceæ the development of embryo follows a variation of *Onagrad* (*Capsella*) type of Johansen, while in *Ulex europæus* and *Sarothamnus scoparius* Souèges (1947 *a* and 1947 *b*) observed an undifferentiated mass of proembryonic cells. In the Mimosaceæ, on the other hand, a massive proembryo without any differentiation into embryo and suspensor has been uniformly reported. However, in the related family Rosaceæ the *Astarad*-type of embryo development has been recorded by Souèges in the genus *Geum.*

SEED COAT

At the time of fertilisation the outer integument is four to five cells thick and the inner integument two cells thick. As the development of the embryo proceeds, the inner integument is more or less completely crushed and disappears. In the outer integument two changes take place. (1) The cells of the outer epidermis of the outer integument become very much elongated. (2) The cell walls of the two to three layers of cells between the inner and outer epidermis become thickened.

SUMMARY

The endosperm becomes cellular only in the micropylar half. It remains free nuclear at the chalazal end, which grows into a multinucleate tube-like haustorial structure. The embryo development in *Cassia occidentalis* L. agrees with the *Asterad* type.

In conclusion, I wish to express my sincere thanks to Prof. A. C. Joshi for his helpful suggestions and criticism during a revision of the manuscript. My thanks are also due to Dr. J. Venkateswarlu for making available to me some literature.

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